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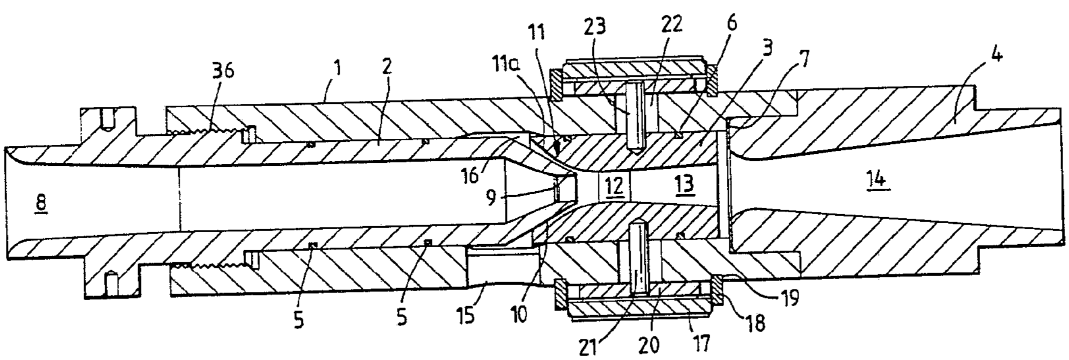
(54) Mixing liquids

(57) Apparatus for blending a first liquid (for instance an ion exchange regenerant) with a second liquid (for instance water) comprises a chamber 16 to which the first liquid can be supplied, an ejector comprising a nozzle 9 and a co-axial throat 12 and an inlet 11 that opens between the chamber and the throat and a diffuser 13 that leads from the throat, a supply 8 for the second liquid to the nozzle 9 and a receiving duct 14 for receiving the resultant blend from the diffuser 13. The nozzle 9 has a conical outer surface 10 and the inlet has a conical inner surface 11a. The nozzle and inlet are axially adjustable relative to one another and manual adjustment means 17 to 23 permit further selective adjustment of the axial spacing between the conical surfaces 10 and 11a. An automatic throat adjustment means may replace the manual adjustment means.



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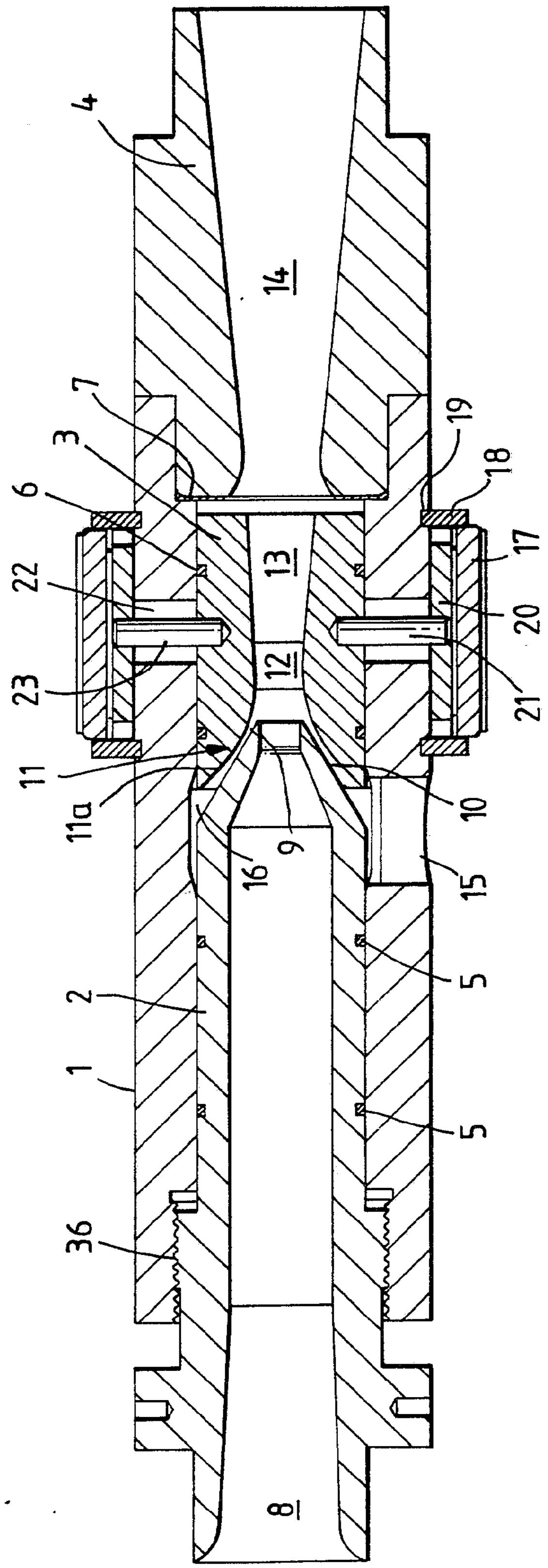

Fig.1.

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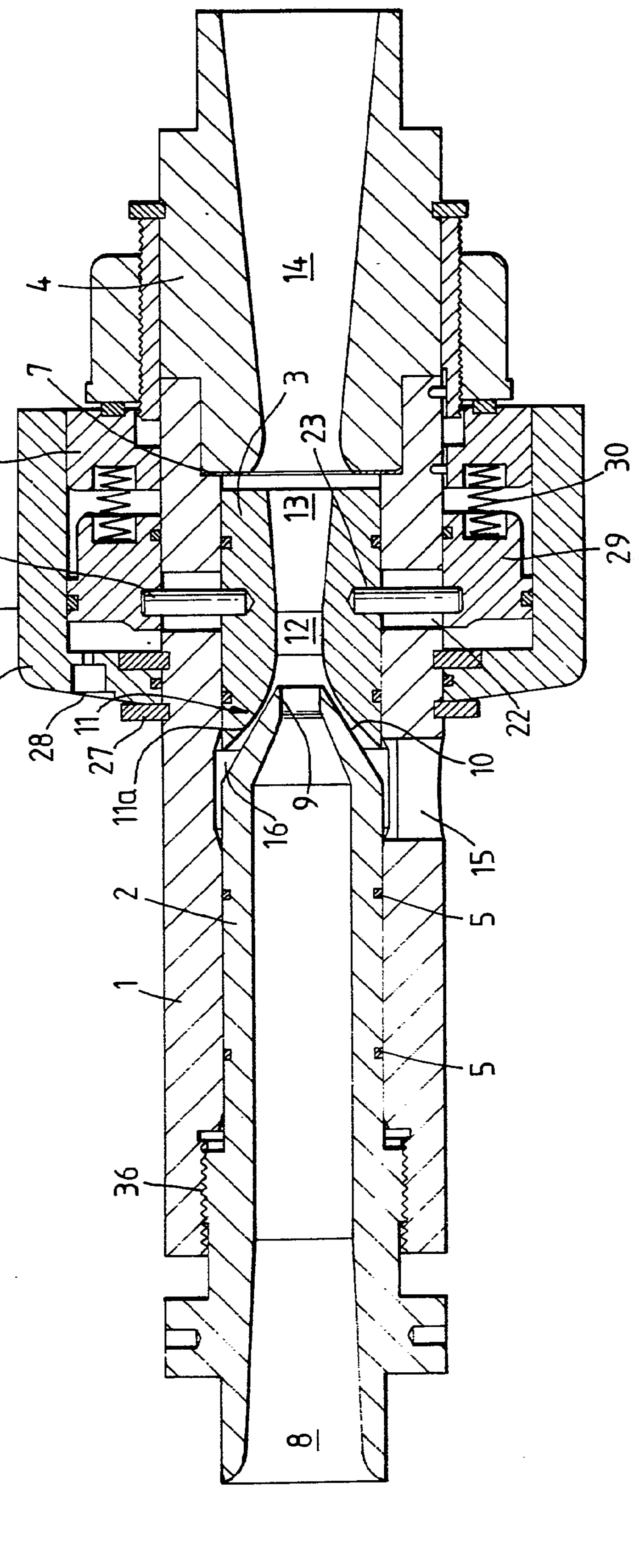

Fig.2.

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Method and Apparatus for Mixing Liquids

There are many instances where it is desirable to blend continuously and quickly a first liquid (for instance a chemical reagent) with a diluent liquid (for instance dilution water).

One method that is used in, for instance, diluting regenerant chemicals used for regenerating ion exchange resins involves use of an ejector comprising an ejector nozzle and an ejector body that is coaxial with the nozzle and that comprises a throat, a diffuser that leads from the throat and an inlet that leads into the throat. Generally the nozzle has a conical outer surface and the inlet has a conical inner surface. The first liquid is supplied to a chamber into which the inlet opens. The diluent is supplied to the nozzle and passes from this into the throat as a jet. . The first liquid is drawn through the inlet into the throat as a result of the Vena Contracta effect caused by the jet of diluent. The two liquids are mixed intimately in the diffuser and are carried away by a receiving duct connected to the diffuser.

The diameter of the nozzle, and its distance from the narrowest part of the throat, are selected such that the jet of diluent has an outer diameter, as it passes through the throat, very slightly less than the inner diameter of the throat. The degree of suction applied by the ejector body to the first liquid depends upon the width of the annulus between the jet of diluent and the inner surface of the throat.

Although the apparatus is often satisfactory it does suffer from a number of serious disadvantages. In particular, the rate of dilution is predetermined by the rate of supply of diluent and by the dimensions of the nozzle and throat.

Accordingly if it is desired to change the rate of dilution whilst maintaining a constant rate of flow of diluent it is necessary to machine the nozzle and/or throat to a different diameter or to replace the nozzle and/or throat with one having a different diameter.

Variations in the processing conditions, for instance in the supply pressure of diluent, give uncontrollable variations in the rate of dilution both because the amount of diluent that is fed to the apparatus varies and because variation in the supply pressure of the diluent may cause variation in the width of the annulus between the jet of second liquid and the throat. For instance if the jet diverges too much the annulus may disappear totally, whereupon little or none of the first liquid will be drawn into the throat.

Another disadvantage is that if the supply of first liquid is to be terminated, for instance upon occurrence of some fault in operating conditions, this generally has to be achieved by closing a valve in the supply to the chamber. Since the first liquid is often a corrosive chemical this necessitates the use of a corrosion resistant valve (which is inconvenient and expensive). Since the chamber always has a finite volume some first liquid will flow even after the valve has been closed. It would be desirable to be able to terminate the supply of first liquid instantaneously.

Apparatus according to the invention for blending first and second liquids comprises

a chamber to which the first liquid can be supplied,

an ejector comprising an ejector nozzle, an ejector throat that is coaxial with the nozzle, an inlet that opens into the chamber and that leads into the throat, and a diffuser that leads from the throat,

supply means for supplying the second liquid to the nozzle under pressure, and

a receiving duct for receiving the blend of first and second liquids from the diffuser,

and in this apparatus the nozzle has a conical outer surface and the inlet has a conical inner surface that can surround the nozzle and the nozzle and the inlet are axially adjustable relative to each other and there are adjustment means for selectively adjusting the axial spacing between the conical surfaces of the nozzle and the inlet.

The second liquid may be referred to as a diluent liquid.

The invention includes a process for blending first and second liquids using this apparatus wherein the second liquid is supplied to the nozzle and the first liquid is drawn into the throat by the suction created in the throat by the ejector, i.e., as a result of the pressure of the jet of second liquid and the dimensions of the throat and inlet relative to the nozzle and the jet.

In the prior art ejectors the feature that controlled the rate of supply of the first liquid into the diluent, at any particular set of operating conditions, was the width of the annulus between the jet and the throat. The spacing between the nozzle and the inlet did not have any significant effect on the amount of first liquid that was drawn into the jet of diluent. In the invention however the amount of first liquid is controllable by this spacing and so by increasing or decreasing the spacing between the two conical surfaces the rate of supply of first liquid can be increased or decreased. Thus the size of the annulus between the nozzle and the inlet will determine the rate of supply of first liquid if the spacing between the inlet and nozzle does not have a throttling action, but the rate can be

reduced by reducing the spacing sufficient to throttle the passage of first liquid into the inlet.

This throttling effect may alter the flow rate of first liquid into the throat both by a true throttling action and by modifying the Vena Contracta effect of the jet in the throat.

Preferably the adjustment means permit continuous adjustment of the spacing although sometimes it is desirable to have adjustment means that permit stepwise adjustment. In particular it can be desirable to have adjustment means that permit both selective and stepwise adjustment so that approximate adjustment can be achieved stepwise and accurate adjustment can then be achieved by the continuous adjustment means.

The adjustment means can be operated manually. For instance continuous adjustment can be by means of a screw thread whilst stepwise adjustment can be by means of a releasable clamp or ratchet mechanism.

The adjustment can be effected automatically in response to a property of the first or diluent liquids or the liquid blend. Thus this property can be measured automatically to generate an electrical signal which can be used to activate a motor that will automatically adjust the spacing. Examples of properties that can be measured for this purpose are the electrical conductivity of the blend (when it is made by diluting an electrolyte with water), the temperature or viscosity of the first and/or diluent liquids, and the pressure of the supply of the diluent liquid to the nozzle. Very wide variations of the rate of dilution can be achieved, the ratio diluent:first liquid typically being in the range 0.5:1 to 100:1. Generally the ratio is at least 1:1 and often it is at least 2:1. Often it is below 16:1.

A particular advantage of the invention is that the supply of first liquid into the ejector can be

substantially entirely shut off if means are provided for substantially closing the inlet by the nozzle, i.e., reducing the space between the conical surfaces substantially to zero. To promote optimum control of the spacing, and thus to improve the degree of closure or seal that can be obtained between the nozzle and the inlet, it is particularly preferred that either or both of the conical surfaces should be curved convexly relative to the other where the surfaces touch one another so as to promote accurate line contact. Generally the conical surface of the inlet is curved convexly.

It is preferred for the adjustment means to include automatic closure means that result in closure of the inlet by the nozzle automatically in response to a predetermined variation in operating conditions. For instance the adjustment means may comprise means for automatic closure and means for continuous and/or stepwise adjustment. The automatic closure means may be activated by variation in a measured property of the blend, the first liquid or the diluent liquid (e.g., the pressure of supply of the diluent liquid to the nozzle). The automatic closure means may also be activated as a result of variation in operating conditions distant from the blending apparatus. For instance it may occur if there is unwanted variation in environmental or other processing conditions associated with the use of the blend.

The preferred apparatus is provided with an automatic control valve in the supply duct leading to the nozzle and which will result in closure of the inlet upon predetermined variation of processing conditions. For instance this valve can include a piston or diaphragm that is actuated by a control fluid, e.g., air or liquid,

or it can be actuated by variations in the pressure of the diluent liquid.

Instead of or in addition to stopping the flow of first liquid by closing the inlet it is also possible to stop the flow of first liquid by operating means for stopping the flow of second liquid to the nozzle, since this will terminate the suction of the first liquid into the inlet. For instance there can be a spring-loaded valve in the supply duct of a diluent liquid which is set to shut the duct if the pressure in the duct drops below a predetermined value.

The invention is of particular value when, as is preferred, the first liquid is a chemical reagent, especially a toxic chemical reagent such as an acid or alkali, since the invention permits accurate control of the rate of supply of this reagent without having to provide a valve or other flow control apparatus in contact with the liquid reagent. In particular the supply of reagent can be shut off automatically merely by closure of the inlet and yet the other liquid, which is generally dilution water, can continue to flow.

The axial spacing between the nozzle and inlet can be adjusted by moving the nozzle whilst keeping the inlet stationary, by moving the inlet whilst keeping the nozzle stationary, or by moving both. Naturally the supplies for the first and diluent liquids and the duct for receiving the blend must be constructed so as to accommodate any movement without permitting escape of liquid. The ejector inlet and throat are preferably part of an ejector body and preferably this body together with the supply for the first liquid and the duct for receiving the blend from the diffuser are held stationary whilst the nozzle and the supply duct for this are moved relative to the ejector body.

The chamber is generally an annular chamber surrounding the inlet and the nozzle. The annular chamber may be defined by the bore of a cylindrical casing that is closed at one end by the nozzle and at the other end by the ejector body. The nozzle and/or the ejector body may slide within the bore relative to the other. When, as is preferred, the ejector body is to be held stationary part or all of the body may be integral with the cylindrical casing and the nozzle (and/or its supply duct) may be in a sliding fit with the bore.

The inlet, throat and diffuser may be integral or the inlet, and generally also the throat, may be a replaceable insert. This has the advantage that replacement of the insert can widen the range of conditions for which the apparatus is suitable. The dimensions of the inlet, throat and diffuser may be conventional.

The supply pressure on the first liquid to the chamber is preferably such that the flow of first liquid terminates when there is substantially no suction by the first liquid through the ejector. Thus the first liquid is preferably present in the chamber at atmospheric pressure or less.

A preferred process according to the invention is one in which the described apparatus is used for mixing a first liquid that is an ion exchange chemical regenerant with a diluent that is water in order to produce a dilute regenerant solution that is then used for regenerating ion exchange resin. Normally the regenerant is diluted from a concentration above 10% to a concentration below 10%, typically 0.5 to 5%, ready for use. The regenrant that is to be diluted may have previously been diluted, e.g., 10 to 25%, but preferably is concentrated regenerant as supplied from the manufacturer, generally having a concentration above 25%. Typical regenerants

are sodium hydroxide (typically supplied as a concentration of 40 to 50%) and mineral acid such as sulphuric acid or hydrochloric acid typically supplied at a concentration of at least 30% (e.g., 30 to 40% hydrochloric acid).

For the dilution of liquids such as these it is often convenient for the diameter of the nozzle to be from 5 to 10 mm and for the diameter of the throat to be from 0.3 to 3 mm, usually 0.4 to 1.5 mm greater. However the diameters of the nozzle and the throat can be greater when high throughputs are required. The diameter of the throat is usually from 103 to 125%, often 105 to 115%, of the diameter of the nozzle. The pressure of the dilution water typically is from 2 to 8, preferably 3.5 to 5.5 bar.

The cone angle of the conical surface of the nozzle is generally from 30 to 90 degrees, most preferably 50 to 70 degrees (i.e., the conical surface is at an angle of 25 to 35 degrees to the axis).

The axial spacing between the nozzle and the inlet is generally variable between zero and at least 3 mm.

In the accompanying drawings:

Figure 1 is a longitudinal section through one form of apparatus according to the invention;

Figure 2 is similar section through a different form of apparatus according to the invention.

The apparatus shown in Figure 1 comprises a cylindrical body 1 that encloses a nozzle body 2 and ejector insert 3 and that leads to an outlet coupling 4.

O-ring seals 5 and 6 permit a fluid tight sliding seal between the cylindrical body 1 and the nozzle body 2 and ejector insert 3 respectively and seal 7 provides a fluid tight seal between the cylindrical body and the outlet connection 4.

The nozzle body 2 has an inlet 8 for connection to a supply of diluent liquid, generally water, and terminates in a nozzle 9 having an outer nozzle surface 10 that is conical.

The ejector insert 3 defines an inlet 11 having a conical inlet surface 11 that surrounds the nozzle surface 10 and that leads to an ejector throat 12 which leads to a coaxial diffuser portion 13 that discharges into a continuation 14 of the diffuser in the outlet connection 4.

A duct 15 leads to an annular chamber 16 that leads into the space between the nozzle surface 10 and the inlet surface 11a, and this duct 15 is connected to a chemical reagent or other liquid that is to be diluted by the liquid flowing through the nozzle body 2 from the inlet 8.

The nozzle body 2 is threaded into the cylindrical body 1 by threads 36 and so rotation of the cylindrical and nozzle bodies relative to one another will move the nozzle towards or away from the ejector inlet 11.

The diffuser insert can additionally be adjusted lengthwise relative to the nozzle surface 10 by screwing clockwise or anticlockwise a nut 17 that is held against longitudinal movement by guides 18 in grooves 19 but which is threadably engaged with a shorter nut 20 that is fixed against rotation relative to the body 1 but which carries pins 21 that extend from the nut 20 through holes 22 in the body and into tight fitting recesses 23 in the ejector insert. By rotating the nut 17 the nut 20 is caused to move threadably lengthwise and so the pins 21 also move lengthwise, thereby adjusting the lengthwise location of the insert.

By making at least one of the surfaces 10 and 11a convex (in the drawing surface 11a is convex) and by providing for relatively adjustment of the nozzle to the

inlet, and in particular by providing for adjustment both of the nozzle and the inlet, it is possible accurately to control the dimension of the annular space 16 at the narrowest point between the nozzle and the inlet. As shown in the drawings, the internal diameter of the nozzle is preferably very slightly less than the internal diameter of the throat.

The flow of liquid through the nozzle body 2 can be maintained continuously even if the flow of reagent through the duct 15 terminates through a failure in supply of reagent, and the flow of reagent into the diluent from the nozzle body 2 can be very accurately controlled by adjusting the width of the annular space 16, and can be completely shut off by closing the nozzle surface against the inlet surface.

When it is desired to replace the ejector insert the pin 21 is withdrawn, the outlet connection 4 is removed from the end of the cylindrical body 1, and the insert is removed and replaced by a fresh insert.

The apparatus shown in Figure 2 is similar as regards the cylindrical body 1, the nozzle body 2, the ejector insert 3 and the outlet connection 4 but an automatic throat adjustment is provided in place of the manually operable nut 17 that engages with guides 18 and threaded inner nut 20.

A cylindrical housing 24 extends between an annular flange 25 fixed relative to one end of the housing and an opposite end 26 that is secured between stops 27 against longitudinal movement relative to the cylindrical body 1. An inlet 28 for hydraulic or pneumatic control fluid is provided through the end 26.

There is a piston 29 in a fluid tight slidable fit between the housing 24 and the cylindrical body 1 and a pin 21 extends from this piston through an aperture 22 of greater diameter into a tight fit 23 in the ejector

insert 3. A spring 30 is provided to bias the piston 29 away from the flange 25, so as to tend to close the annular passage 16.

The supply of hydraulic or pneumatic fluid to the inlet 28 can be controlled in response to variations in the flow of liquid through the nozzle body 2 or of the content or rate of flow through the duct 15 or to a physical property, for instance, conductivity, in the blend leaving the diffuser 14. If the hydraulic or pneumatic fluid supply is shut off, the spring 30 will cause the piston 29 to move to the left so as to close the annular passage 16.

CLAIMS

1. Apparatus for blending first and second liquids and which comprises

a chamber to which the first liquid can be supplied,

an ejector comprising an ejector nozzle, an ejector throat that is coaxial with the nozzle, an inlet that opens into the chamber and that leads into the throat, and a diffuser that leads from the throat,

supply means for supplying the second liquid to the nozzle under pressure, and

a receiving duct for receiving the blend of first and second liquids from the diffuser,

and in this apparatus the nozzle has a conical outer surface and the inlet has a conical inner surface that can surround the nozzle and the nozzle and the inlet are axially adjustable relative to each other and there are adjustment means for selectively adjusting the axial spacing between the conical surfaces of the nozzle and the inlet.

2. Apparatus according to claim 1 including means for substantially closing the inlet by the nozzle and thereby substantially shutting the supply of first liquid into the ejector.

3. Apparatus according to claim 2 in which either or both of the conical surfaces are curved convexly relative to the other.

4. Apparatus according to claim 3 in which the conical surface of the inlet is curved convexly relative to the surface of the nozzle.

5. Apparatus according to any preceding claim including automatic closure means that result in closure of the inlet by the nozzle automatically in response to a predetermined variation in operating conditions.

6. Apparatus according to claim 5 in which the automatic closure means result in closure of the inlet by

the nozzle automatically in response to variation in a measured property of the blend or of the first or second liquids.

7. Apparatus according to any preceding claim including also operating means for stopping the flow of second liquid to the nozzle.

8. Apparatus according to any preceding claim in which the ejector inlet and the ejector throat are part of an ejector body and in which the body, together with the supply for the first liquid and the duct for receiving the blend from the diffuser, are held stationary whilst the nozzle and the supply duct to the nozzle are movable relative to the ejector body.

9. Apparatus according to claim 8 in which the chamber is an annular chamber defined by the bore of a cylindrical casing that is closed at one end by the nozzle and at the other end by the ejector body.

10. Apparatus according to any preceding claim in which the ejector inlet is in a replaceable insert.

11. A process for blending first and second liquids using apparatus according to any preceding claim, in which the second liquid is supplied to the nozzle and the first liquid is drawn into the throat by the suction created in the throat by the ejector.

12. A process according to claim 11 in which the second liquid is water, the first liquid is an ion exchange chemical regenerant and the blended liquid is a dilute aqueous regenerant solution, and in which this solution is used for regenerating ion exchange resin.

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